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RASPBERRY GROWING IN NEW YORK STATE: CULTURAL PRACTISES AND DISEASE CONTROL

GEORGE L. SLATE AND W. HOWARD RANKIN

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Bulletin No. 625

RASPBERRY GROWING IN NEW YORK STATE: CULTURAL PRACTISES AND DISEASE CONTROL

GEORGE L. SLATE and W. HOWARD RANKIN

GENERAL CONSIDERATIONS

WHY RASPBERRY GROWING DECLINED

This bulletin brings together for the raspberry grower a summary of the experiments and observations in New York concerning the factors that have a decided influence on the yield and quality of the fruit. For many decades raspberries have been a popular and profitable crop with the small fruit growers of this State. In several sections of the State they have assumed the proportions of a major crop. The acreages devoted to raspberries in these sections have varied widely with successes and failures, according to the merits of the varieties grown, the special markets developed, and the diseases that became prevalent. In recent years the raspberry acreage has been greatly reduced and growers have turned to other crops. The past decade has witnessed a recession in red raspberry culture in the mid-Hudson Valley due to disease losses, a curtailment in black raspberry production in the Finger Lakes region due to lack of demand for evaporated fruit, and at the present time a reduction is in progress in the purple Columbian raspberry acreage in western New York due apparently to a change in demand for that berry as a preserved product.

During these readjustments in acreages in the sections where raspberries have been extensively grown, there exists an excellent opportunity for the careful appraisal of all the factors concerned in the profitable production of this fruit crop. Much of the general reduction in acreage has been due to the ravages of the dreaded mosaic diseases and growers whose plantings were rendered unprofitable have hesitated to reestablish their plantings. In recent years investigations on these diseases have shown clearly that with proper and relatively simple precautions the mosaics need no longer be feared. The mosaics are not new troubles for one or more of the diseases of this type has been present in the raspberry fields of this State for many years. In 1880, E. P. Roe, in his book entitled *Success with*

Small Fruits, made this statement regarding the Hudson River Antwerp variety in the Hudson Valley: "A disease called the 'curl-leaf' is destroying some of the oldest and largest plantations, and the growers are looking about for hardier and more vigorous varieties."

In Ulster County, particularly, the growing of red raspberries for the fresh fruit market in New York City is an old established industry, dating back at least to 1859. Altho the history of the running-out of raspberry varieties in this region is not definitely known, many different varieties in turn have been successfully grown for a time and then discarded.

A bulletin (No. 226, now out of print) of this Station called attention to the running-out of the variety Marlboro in Ulster County in 1902, and described clearly for the first time one of the mosaic diseases as the cause. New varieties have been originated in this region from time to time and the variety Perfection practically superseded all others shortly after it was introduced about 1910. After a few years, yellow mosaic became prevalent in this variety and it was no longer profitable because of diminishing yields and inferior quality of the fruit. During 1920 and 1921, many growers plowed up their Perfection plantings and by 1924, only a few small plantings could be found. There were many growers in Ulster County who had previously marketed one carload or more of red raspberries annually. No new variety had proved suitable in the district to take the place of Perfection and by 1924 the industry was practically extinct in the lower Hudson River Valley.

The striking failure of Perfection is a recent example of what has been occurring for decades in varying degrees in this and other sections of northern United States. It has been the history of red raspberry culture that the mosaic diseases have caused varieties to "run-out" and new selections have been constantly in demand. Black raspberries and the hybrid purple varieties have been subject to similar failures in certain sections.

THE INDUSTRY AT PRESENT

At the present time there is a movement to reestablish profitable red raspberry culture in the Hudson Valley to supply the fresh fruit market of New York City. In western New York, particularly in the section around Brant and North Collins, a group of cooperating growers are attempting to increase yields and profits by growing better varieties of red and black raspberries free from the mosaic

diseases. Also, there seems to be a general interest on the part of many growers to turn to raspberry culture in the present economic upheaval. That there are reasonable chances for profit in increased acreages of raspberries is brought out by the census figures for the past 30 years.

A study of recent census reports shows in a striking manner the reduction in raspberry acreage in this State, and indicates to some extent the limits to which the acreage may be expanded. In 1899, the acreage in raspberries in New York was 12,376. By 1929 the acreage had decreased to 7,837, a decrease of 37 per cent. An examination of the figures reveals that during the same period Chautauqua and Erie counties increased their acreage from 1,044 to 2,401. The Ontario lakeshore counties from Niagara to Oswego had 3,930 acres in 1899, but in 1929 the acreage in this section was only 1,254. The Finger Lakes region and adjoining counties decreased their acreage from 3,847 to 2,376 in the same period. In the Hudson Valley the decrease in acreage was from 1,648 to 1,112. In the remainder of the State the acreage in 1899 was 1,940 and in 1929 it was 1,257.

In the adjoining states of Ohio, Pennsylvania, and New Jersey and in the New England states which are the only states that offer serious competition on the markets within shipping distance of New York, the combined acreage decreased from 14,112 in 1899 to 9,129 in 1929, or 35 per cent. The combined acreage of New York and the adjoining states in 1899 was 26,488 and in 1929 it was 16,966, a decrease of about 36 per cent.

The average yield per acre in this region decreased in the 30 years from 1,315 quarts to 829 quarts, a decrease of 37 per cent. The total production decreased from about 35 million to 14 million quarts, or 60 per cent.

During the period 1899 to 1929 the total population of the states of New York, Ohio, Pennsylvania, New Jersey, and New England increased from 25,201,240 to 41,073,788, or 63 per cent.

It is evident from these figures that the acreage in raspberries in New York and competing regions has decreased 36 per cent and that due to decreased yields per acre production has dropped by 60 per cent, whereas the population has increased 62 per cent. On the basis of these figures the raspberry growers of New York State would need to plant over 4,500 acres to bring the acreage up to that of 1899. If we assume that the 62 per cent increase in population will consume raspberries at the rate they were consumed in 1899 and that the yields

would be restored to the 1899 figures, about 7,700 additional acres would then be needed. If the adjoining states do not increase their production, or if New York is able to grow better raspberries at a lower cost, then there are possibilities for even more extensive planting.

These statistics are not presented with the intention of starting an extensive boom in raspberry production. They are presented to make clear the fact that the acreage and the yields per acre are much lower than the region under discussion has supported in the past. Raspberries require a good soil. In fact, the value of the crop is such that the grower is justified in devoting his best land to it. For this reason a material increase in raspberry acreage might well replace the acreage of some of the other crops, fruit or otherwise, that are at present unprofitable. The prospective planter, especially if he has not had previous experience with raspberries, should start with a small acreage and increase his plantings gradually as his markets and experience develop. Growers in regions of high production may well consider the possibility of planting a variety like Newburgh that is well adapted to shipping and thus develop markets in cities not located near raspberry-producing areas.

RASPBERRY GROWING HIGHLY SPECIALIZED

Success in raspberry culture depends very largely on the capability of the grower to supply suitable conditions and to apply specialized methods. No detailed instructions can be prescribed for individual conditions, but there are certain fundamentals in soil and site selection, cultural methods, and disease prevention that each grower must weigh intelligently. Where doubt exists or speculative risks are indicated, the better judgment is to learn slowly by experience on a small scale.

Those who are contemplating the planting of raspberries may well consider some of the advantages that raspberries offer. A relatively small amount of capital is required as most of the machinery needed for berries is already on the average farm. Spraying equipment is usually not necessary and graders, packing houses, and cold storage are not needed. It is not necessary to start with a large acreage to reduce the overhead on equipment. The grower may readily grow his own plants and expand his acreage without additional cash outlay.

It is relatively easy to get out of raspberry production should the planting become unprofitable thru overproduction, disease, or an unfavorable location. The canes may be mowed off and plowed out,

whereas the elimination of a bearing orchard of a tree fruit is a more difficult matter. Because of the ease of discarding a planting, the grower can respond more readily to market changes, test new varieties quickly and easily, and soon have these new sorts in commercial production should they prove desirable.

Returns are early in comparison with tree fruits. A partial crop of raspberries may be expected the second year and a full crop the third year. After that, barring unusual weather conditions, a full crop may be expected each year which is not the case with the biennially bearing tree fruits.

The crop is quickly sold and the money soon in the grower's hands at a time of year when little is coming in from tree fruits.

Cheaper labor may be utilized for most operations than with the tree fruits. Pruning is less difficult, and no thinning or grading is necessary.

The control of diseases and insects is much simpler. Mosaics are the most serious diseases, but they require no spraying and may often be eliminated with the spade. An intelligent consideration of the control measures and proper planning before establishing the planting may render further measures unnecessary. Mosaic control requires planning as to the kind and source of planting stock, selection of a site where mosaic control is practicable, and careful supervision by eliminating any diseased plants that appear the first two seasons. These measures need not add greatly to the expense and, if intelligently applied, will solve to a considerable extent the one factor that has most hampered profitable raspberry culture in recent years. A few resistant and mosaic-escaping red varieties now available furnish a partial solution of the problem. The susceptible and non-escaping red varieties and the black varieties require special treatment which should repay the grower. Many of the insect pests may be controlled with the pruning knife. The grower who has fought the eternal fight with apple scab, codling moth, maggot, and spray residues will appreciate the comparatively simple measures necessary to protect raspberry fields.

Raspberries bloom late in the spring after frosts are past, they are self-fruitful, the weather is warm and bees abundant, consequently there is no pollination problem.

The fruit is well known and popular on the market for both table and culinary purposes.

Competition from distant producing areas is light because of the

perishability of the product. Since raspberries do not thrive in the South, the demand for them is not partially satisfied by early shipments, as is the case with strawberries, and local raspberries are usually in good demand thruout their season.

Raspberries fill in a gap on the fruit farm between cherries and strawberries and the later fruits such as peaches, plums, and early apples.

Before extensive plantings are made the grower should first consider his markets. The local market has the advantage of low transportation charges. If the fruit is sold locally or from the roadside stand, an intimate contact with marketing agencies and consumers is maintained. This contact enables the grower to get his customer's reaction to packages, new varieties, and condition of the fruit. Varieties that do not ship well but that possess other desirable characters may often be grown to advantage for the nearby market. Financial returns are usually quicker from the local market. The grower should therefore make sure that his local markets are well supplied with berries before consigning his fruit to the more distant general market. Whenever possible, contact with several markets is desirable in order to permit diversion of fruit from a glutted market to one that is not over supplied.

The distant, or general market, which is usually one of the larger cities of the country, must often be the outlet for regions of high production. Convenient and rapid transportation to these markets is essential. Here, as with the local markets, the possibilities of several cities should be considered. The grower who intends to ship the bulk of his crop must necessarily plant varieties that will endure the handling incidental to getting the fruit on a distant market, and facilities for quick cooling of the fruit as soon as picked may be necessary.

A third possibility is a nearby canning factory or preserver. The rapid increase in the use of frozen raspberries may make the freezer an outlet for the crop in areas of intensive production. Too much reliance should not be placed on this outlet since large quantities of frozen raspberries from the Pacific Coast are available to eastern users at prices that will not permit the eastern grower profitable returns from his crop. For a while at least the most profitable outlet will continue to be the fresh fruit market.

Often a market that is abundantly supplied with fruit may be receiving so much inferior fruit that a fancy product can be disposed of profitably if the grower will persist in making his wares known to retailers and consumers.

In some cases, especially for women, the manufacture of jam or canning may dispose of an unmarketable surplus. This product may often be marketed at a roadside stand to good advantage.

An abundant supply of labor is essential for picking. When possible the grower should have a sufficient diversity of berries and other fruits to keep the pickers busy thruout the summer.

The average and low profit acreage at present far exceeds the highly profitable due largely to neglect to provide necessary cultural practises and to eliminate the losses due to the mosaic diseases. That these losses in yield and quality are preventable is well established by examples where growers observe the proper methods. As improvements in varieties, cultural practises, and disease control make it possible to increase unit area profits of any crop, it inevitably happens that the increasing acreage in the hands of the progressive and specializing grower reduces the chances of the average grower to compete in the market. Raspberry growing in New York is apparently at this stage. Those growers who have favorable soil conditions and are willing to exert the extra effort to apply specialized methods can be reasonably sure of obtaining the yields and quality that need only a successful marketing program to insure profit. The mosaic diseases will continue to be the chief cause of failure to realize the full possibilities of yield and quality when nothing is done about their prevalence in the planting stock or when mosaic-free stock is set adjoining diseased plantings. The principal difficulty has been that the necessary knowledge and effort to utilize such knowledge have not been widely incorporated into practise.

SELECTION OF THE SITE

No factor contributes more to the profitable production of raspberries than the site. The returns from a high yielding raspberry field are such that the grower can afford to devote his best land to the planting. In selecting a site the grower is limited to the land in his possession, but the average farm is usually sufficiently variable to justify the giving of considerable thought to the selection of the field.

A suitable soil is of the utmost importance. The ideal soil is a fine deep sandy loam, well supplied with humus and retentive of moisture, but well drained. Raspberries often do well on lighter and heavier soils. Good crops may be obtained on well-drained clays but this type is hard to work and bakes quickly. Where crown-gall is

a factor the heavier type may be preferable. Fruiting and cane growth come at a time when soil moisture is low, consequently the soil that is retentive of moisture is to be preferred. Some varieties have a decided preference for certain soil types. June prefers a clay soil, Cuthbert likes a lighter soil, and Latham is more cosmopolitan in its requirements. The soil reaction is not important, altho raspberries are usually thought to prefer a slightly acid soil.

If the grower is contemplating the production of plants, especially the tip-rooting varieties, a light soil is absolutely essential. The tips root with difficulty in clay, the plants are small, and the root systems weak. Digging is slow and expensive and the plants are far inferior to those grown on the lighter soil. It is often impossible to dig plants in the spring until growth is so far advanced as to result in considerable injury to the plants.

Good drainage contributes much to the success and long life of the plantation. Studies at the Michigan Experiment Station have shown that root development and penetration are closely correlated with the height of the water table. A high water table was accompanied by poor root development and a low water table with extensive root development. Cane growth, yields, and longevity of the plants were directly proportional to root development and height of water level.

The root system of a raspberry plant in a good soil extends to a depth of 3 feet with the bulk of the roots in the upper 2 feet of soil. Consequently, the water level should not come nearer the surface than 3 feet for more than a few days. A gentle slope is advisable for surface drainage during heavy rainfall or rapidly melting snow.

Poor drainage is responsible for much winter injury, the wet soil stimulating late autumn growth which fails to ripen properly. A soil that is saturated a few weeks during the growing season may cause the death of the plants at that time.

An abundance of humus is valuable in improving the moisture-holding capacity and fertility of the soil. A heavy soil well supplied with humus works more easily and bakes less than one deficient in that constituent. Soils deficient in humus should be built up in organic matter before the plants are set. An application of 20 tons or more of manure to the acre will add considerable humus, or a heavy growth of some green manure crop may be plowed under. This is preferably done a year in advance of planting the berries.

Air drainage is usually of less importance than the other factors, but it should be considered. "Pockets" or low spots surrounded by

higher ground or any configuration of the land or trees that tends to dam up the downward flow of cold air are colder in winter and more subject to frosts. Plants in such spots are more subject to certain diseases that depend on moisture on the foliage or cane for their incidence. Mildew on Latham is much more serious where air drainage is poor. Heavy infections by the fungi causing anthracnose and spur-blight are also favored by poor air drainage.

The exposure of a piece of ground influences directly the season of ripening of a variety, a southern exposure being earlier than a northern one. Hence the season of a variety may be accentuated by planting early varieties on a southern slope and late varieties on a northern slope. A north slope is usually cooler and the soil dries out less rapidly.

Protection from wind prevents breakage of canes and loss of fruit from whipping. A protected field is more comfortable for pickers in cold weather, and they are less annoyed by the movement of the canes. On the protected field snow drifts less and remains longer. There is less evaporation from the soil and the canes, and consequently less winter injury.

The fewer weeds on the intended site, the easier it will be to care for the planting. Any serious weeds, such as quack, should be eliminated before the plants are set. It is practically impossible to clean out quack grass in an established berry field, and it is usually cheaper to set a new planting than attempt to clean up one infested with grass.

As a general rule it is inadvisable to plant raspberries immediately after raspberries or immediately adjoining an old neglected planting, for the new planting may inherit some of the insects and diseases of the old planting.

PREPARATION OF SOIL AND PLANTING

Thoro preparation of the soil is of prime importance in getting a good stand of plants and sufficient cane growth for a light crop the second year. Whenever possible it is desirable to start preparing the field for berries 2 or 3 years in advance. Weeds should be eliminated, humus provided either by stable manure or green manure crops, and a hoed crop should be grown 1 year before the raspberries are set.

Deep plowing, 6 to 8 inches, followed by thoro disking and harrowing will fit the ground satisfactorily. The soil must be well pulverized and mellow.

Altho spring setting is generally advised by various authorities, fall planting has been very successful with the red varieties at this Station. Fall planting permits the work to be done at a comparatively slack time, lessens the danger of the roots drying out as the weather is cooler, and generally provides more time to fit the ground properly. Plants purchased from nurseries in the fall are fresh out of the ground, whereas plants purchased in the spring may have been stored thruout the winter under not too favorable conditions. Fall-set plants become thoroly established during the winter and are off to a good start in the spring. To prevent heaving out of the newly set plants during the winter, plow a furrow up to the row of plants or mulch them with a strawy manure. This furrow should be worked down in the spring.

Spring planting should take place as early as the ground can be fitted, since the early set plants become established before the weather is hot and dry. Growth of new shoots from the base of the cane starts early and there is danger of breakage if they are not set early. Late spring setting often results in poor stands if weather conditions are unfavorable.

The black and purple raspberries are always set in the spring. Some growers wait until the tip plant is well started before moving it to the new planting. The writers are inclined to doubt the wisdom of this practise. The young tip plant even before growth starts is fully equipped with a good root system and buds from which the new canes will develop, and it needs no more help from the mother plant. The chief harm done by delaying the removal of the tips is to the parent plant which may not be pruned until the foliage is well advanced. Cultivation is also delayed, weeds become established, and the plants receive a decided setback. Also, the anthracnose fungus often becomes established on the new plants, and this becomes an immediate cause of injury the first year.

The plants are set at about the same depth or slightly deeper than they grew previously. The tops of the red raspberries are cut back to a height of 6 inches before setting, this length of cane being left to mark the row and facilitate handling. If too long a cane is left the plant may die before becoming established. No fruit should be expected the first season. The cane or "handle" on the black and purple varieties should be removed entirely if anthracnose is present.

The operation of setting is commonly done in one of two ways. The row is furrowed out with a plow, the plants are set against the straight

side of the furrow, partially covered, and later the furrow is filled with the plow. With the other method, two men constitute a planting team; one opens the ground with a spade, the other thrusts the plant into the hole, after which the spade is again inserted in the ground and the soil pressed against the plant. Care should be taken with both methods to firm the soil so tightly against the roots that the set plant will resist a strong tug without loosening. Care should be taken not to set the plants too deep or the growing points may not be able to break thru; if set too shallow the plants may dry out. In light soils red raspberries may be set as much as 3 inches deeper than they grew, but tip plants only an inch or two deeper.

During the operation of setting the plants should not be permitted to dry out at any time. They may be wrapped in wet burlap or kept in tubs of muddy water. Only as many plants as can be set before the roots dry off are dropped ahead of the planting crew.

The distances for setting the plants are determined by the system of culture which is to be followed. Red raspberries are usually set about 5 feet apart each way in the hill system. The black and purple varieties require 5 or 6 feet each way if grown in hills. In the hedge row system the rows are 7 or 8 feet apart, the red varieties being set 2 or 3 feet apart in the row and the black varieties 3 to 4 feet. If a tractor is to be used for cultivation, the rows will need to be 8 or 9 feet apart.

PLANTING STOCK AND PROPAGATION

Red raspberries are propagated by using the suckers that spring up from the roots. These sucker plants may be set directly in the field or may be grown a year in the nursery row after which they are known as transplants. The higher cost of large size sucker plants or transplants that have grown a year in the nursery row is not warranted as the smaller sizes will give as good a stand of plants. For home use the transplant may be desirable since it need not be cut back as severely as the sucker plant and consequently may produce some fruit the first season.

The grower who raises his own red raspberry plants will find it inadvisable to dig suckers freely thruout the field as considerable injury to the old plants may result. It is better to set aside a portion of the field for propagation purposes and dig all the plants. Enough pieces of roots will be left in the ground to grow another crop of plants. If this is done continuously the ground must be kept very fertile with

manure and fertilizer otherwise the field will soon run out. Plants should not be dug until the grower is ready to set them. If it is necessary to dig them much in advance of setting they may be heeled-in in a shady moist spot, preferably the north side of a building. If the soil is well packed around the roots the plants will remain in good condition until needed.

Another method of propagating the red varieties that is popular with some growers is the setting of the young green sucker plants early in June, or as soon as they are a few inches in height. The sucker is dug carefully as soon as the new roots are well started, care being taken to get a piece of the old root. Unless the weather is moist and cloudy and rain comes soon, many plants are usually lost. The production of an abundance of sucker plants may be stimulated by striking a spade into the ground around the old plants or by deep cultivation to break off the roots, each piece of which will send up a new sucker. This method is of value for the rapid increase of stock of new varieties. It also permits the selection of healthy, disease-free plants as mosaic may be readily detected on the foliage of the suckers.

The black and purple varieties are propagated by tip layering, commonly known as tipping. Late in the summer, usually about the end of August, the ends of the canes droop to the ground, the tips become somewhat snakelike in appearance with small curved leaves, and develop roots if in contact with moist, mellow soil. As only a small proportion of the tips root naturally, they are buried by the grower to make certain that they will remain in one place and develop roots. This is usually done by opening a hole in the soil with a spade or trowel, inserting the tip vertically to a depth of 3 inches, and pressing the soil against the buried tip. By fall the tip will have developed a good root system and the following spring it is dug and severed from the mother plant. This young plant may be grown a year in the nursery and set or sold as a transplant. For most conditions the tip plant is satisfactory, and the additional cost of transplants is not warranted.

Tip plants are very delicate and easily injured. At no time should they be permitted to dry out. They do not ship well and whenever possible the grower should raise his own plants or purchase them from nearby plantings. Tips grown on sandy or mellow loamy soils are far superior to those grown on clay. On a clay soil many roots are destroyed and the cost of digging is prohibitive.

REGULATIONS REGARDING SALE OF RASPBERRY NURSERY STOCK

Most raspberry nursery stock at present is obtained from fruiting plantings. Regulations in most states require that nursery stock may be sold only from plantings that are relatively free from the mosaics and other similar diseases. The grower who desires to sell raspberry plants must apply before June 15 to the Department of Agriculture and Markets in Albany for an inspection. The nursery inspector must see the planting in mid-summer and will certify the planting if not more than 8 per cent diseased plants are found and if the diseased plants are immediately removed. Certain isolation requirements, according to local conditions, must also be observed. While this process insures that raspberry nursery stock legally sold is relatively free of mosaics and other diseases, it does not insure that all certified stock is identical as to disease content. Stock from a planting which for two or three seasons has been very vigorous and has shown not more than 1 or 2 per cent diseased plants is to be preferred over stock from a non-vigorous planting showing 5 to 8 per cent. A few growers have developed stock of certain varieties exceptionally free of mosaic.

SYSTEMS OF PLANTING

Red raspberries may be grown according to several systems. When grown according to the hill system, which is popular in the Hudson Valley, the plants are set 5 by 5 feet and may or may not be staked. The hill system has the advantages of permitting cross cultivation, thus eliminating considerable hoeing, and of making harvesting somewhat easier. The disadvantages of this system are the lower yield resulting from the small number of canes to the acre, a more rapid rate of spread of mosaic, and the leaving of a much larger hole in the field when the diseased plants are removed than would be left by removing the same number from the hedge row.

The wide hedge row which is often 2 or 3 feet wide has several marked disadvantages and is not to be recommended. The fruiting laterals in the center of the row are crowded and many die, berries are overlooked by the pickers, and are either lost or picked later when over-ripe, weak canes are produced which bend over and allow the berries to get dirty, and fungus diseases dependent upon moisture for their incidence may be more severe on the shaded canes of a wide row.

The narrow hedge row is perhaps the most suitable system for New York. In this system the rows are 7 or 8 feet apart, or more if a tractor is to be used for cultivation. The row is restricted by cultivation and pruning to a width of 1 foot. Because of the large number of canes to the acre greater yields are possible than with the hill system, and because of the narrowness of the row, the faults of the wide hedge row are eliminated.

In the linear system, which is popular on the Pacific Coast, only the original plants are kept for fruiting and all suckers are removed. A minimum of hand-work is necessary with this system.

The black and purple raspberries are usually grown by the linear system with the plants set 3 to 4 feet apart in rows 7 or 8 feet apart. If grown in hills, they are spaced 5 or 6 feet apart each way.

In the past raspberry plants have been supported extensively, especially in the Hudson Valley. Many growers are abandoning the use of supports and with many varieties it is not essential. Supports are expensive and one can afford to lose many berries before resorting to them. Severe pruning may obviate the necessity for support in some cases. The advent of the Newburgh raspberry with its low habit of growth, long fruiting laterals, and very heavy crop may revive the use of supports, and for that reason a simple trellis is described.

A series of posts are set in each row at intervals of 15 to 30 feet. Near the top of each post is nailed a cross piece about 18 inches long. The height of the post depends on the height of the canes, but will usually be from 3 to 4 feet above the ground. A wire is run along each side of the row and attached to the ends of the cross pieces. The canes are allowed to hang over the wires or may be tied to them.

Another method is to run a single wire down the center of the row and attached to posts at a height varying from 3 to 5 feet, depending on the length of the canes. The canes are tied to this wire.

Several other methods of supporting raspberry canes are described and illustrated in United States Department of Agriculture Farmers' Bulletin No. 887, which may be obtained on request from members of Congress.

CARE OF PLANTATION

The care received by the new planting is the chief factor responsible for its success, assuming, of course, that the grower has set healthy stock on a suitable location. A perfect site and healthy plants are of little avail if they are neglected. On the other hand, excellent care

may to a certain extent overcome some of the defects of a poor location, and may even temper the ravages of disease. While formulating his plans for caring for the planting, the grower should always keep in mind the fact that the returns from a well cared for raspberry field may be high and that his extra efforts will be well repaid.

Every effort must be made to conserve moisture. The growth of the canes and the ripening of the berries takes place in midsummer when the supply of moisture is often deficient. Moisture, more than any other factor, is responsible for berry size, and consequently heavy yields. Thoro cultivation is one of the most effective methods of conserving moisture. Cultivation begins soon after planting and in an established planting as soon as the ground can be worked in the spring. It should be shallow at all times and sufficient to keep down weeds and prevent a crust from forming.

Raspberries are shallow rooted and easily injured. Four inches is sufficiently deep and it is advisable to shorten the cultivator teeth next to the plants. If quack grass appears in the new planting it must be subdued at once, as it is impossible to eradicate after the rows are filled with canes. Suckers are not allowed to grow between the rows. An occasional hand hoeing is necessary to clean out weeds between the plants. If grass becomes established between the canes it is usually cheaper to take out the planting and set another than to attempt to clean out the grass.

Cultivation should not be continued much beyond the picking season as the growth stimulated by late cultivation will not mature sufficiently to withstand the winter. Every effort should be made to stimulate rapid and vigorous growth of the canes early in the season, so that late growth will not be necessary to provide fruiting wood for the following season. During the picking season it may be necessary to suspend cultivation to prevent knocking off of berries or the breakage of canes that may have bent over from the weight of the fruit. If the canes are trellised cultivation may continue thruout the picking season, unless the soil is too dusty.

After the picking season is over the ground may be prepared and a cover crop sown. Cover crops are rarely used in raspberry plantings in this State, but they are very useful and deserve the attention of every grower of raspberries. Not only do they add considerable humus to the soil, but what is more important, they aid very materially in ripening the canes by competing with them for food and moisture during the fall, thus preventing rank growth and consequent winter

injury. In some experiments in Missouri the effectiveness of the cover crop was increased by fertilizing with a nitrogenous fertilizer. The increased growth of the cover crop as a result of the fertilization used up more soil moisture and permitted better ripening of the canes. The cover crop is more valuable in a wet fall than in a dry one.

Suitable cover crops are barley, oats, buckwheat, and golden millet, and they have the advantage of not living over winter. Crops which live over winter should be drilled so that they will not become established between the plants as weeds the following season. The cover crop may be turned under early in the spring, or if the land is not subject to washing, this may be done in late fall after growth has ceased.

In late fall it is customary, especially on heavy soils, to plow a furrow towards the plants for winter protection of the crowns. If there is danger of water lying on the ground during the winter, this furrow will carry off the surplus. In the spring the ground may be levelled with a cultivator.

In the spring on the heavier soils it may be necessary to plow or disk the space between the rows before starting cultivation. This should be shallow, not over 6 inches in the center or 3 or 4 inches next to the plants. After this plowing the land may be worked as usual with the cultivator.

If a suitable mulching material, such as hay, straw, leaves or similar substances, is available it may be used to very good advantage instead of cultivation. Apply it between the rows to a depth of 4 to 6 inches, but be sure the mulch is free from weed seeds. The first 2 years the mulch is on the field it may be necessary to fertilize liberally with a nitrogenous fertilizer to compensate for the nitrogen required by the organisms which are rotting the mulch. Eventually the mulch itself as it becomes incorporated in the soil, will supply considerable nitrogen.

During the first season there is considerable unoccupied space between the rows which may be utilized by an intercrop, such as beans, peas, summer squash, cabbage, or cauliflower. Tomatoes and early potatoes should not be interplanted with raspberries owing to the susceptibility of the raspberries to the wilt disease which may be brought to the field by the tomatoes and potatoes. Crops should not be grown near enough to the berry plants to compete with them for moisture and food. After the first season no other crop should be grown, as the berry roots occupy the ground.

FERTILIZING

There is little definite information as to what fertilizers are profitable on brambles. On reasonably fertile soils well supplied with humus, fertilizers may not be needed. The limiting factors in cane growth and fruit production are usually moisture, humus, poor drainage, poor culture, and disease. In a field where cane growth is unsatisfactory these conditions should be attended to before resorting to fertilizers. Fertilizers applied to a field in which something besides plant food is the limiting factor are largely wasted.

Phosphoric acid and potash have not been shown to be profitable in fertilizer experiments with raspberries and their use is not recommended. When cover crops are used, it may be necessary to apply 300 to 400 pounds of superphosphate per acre for the cover crop, and in the case of a non-leguminous cover crop some nitrogen may be necessary. This must be determined by the grower himself by observing the growth of the cover crop.

In an experiment at Cornell nitrate of soda nearly doubled cane growth of Cuthbert, but without a corresponding increase in yield of fruit. The Michigan Experiment Station in reporting the results of a fertilizer experiment with black raspberries which was conducted in a field described as exceptionally good arrived at the following conclusions: Nitrogenous fertilizers applied about mid-September, in the spring, or in early August resulted in a heavier early season production of fruit. The use of fertilizers on vigorous plants was probably not profitable. On vigorous plants the size of berries was not increased materially. The evidence did not show that yields were materially increased by fertilizing in fields producing only moderate crops.

Since we know that there is a general correlation between the vigor and productivity of a plant, it seems desirable to stimulate the development of strong vigorous canes. Before using fertilizers the grower must therefore determine whether he is satisfied with the present growth and vigor of his plants. If it seems desirable to stimulate additional growth the use of nitrate of soda or sulfate of ammonia at the rate of 250 to 300 pounds per acre is suggested. Excessive amounts of nitrogen should be used with caution since an overdose of this element tends to make the berries soft and difficult to handle. It must be applied between the rows and not directly on the crowns of the plants. In view of the danger of stimulating late autumn growth, it is suggested that the fertilizer be applied early in the spring just as or slightly before growth starts.

When it is available, stable manure applied annually at the rate of 10 tons to the acre is always worthwhile. In addition to furnishing plant food, the stable manure will aid very materially in building up the humus supply and moisture-holding capacity of the soil, as well as improving its physical condition. Hen manure is frequently used on raspberries with good results. It is valuable chiefly for its nitrogen which varies in amount from 0.5 to 1.5 per cent and averages about 1.0 per cent. Where the amount of nitrogen in the hen manure is known, enough manure should be applied to furnish about 50 pounds of nitrogen per acre. Besides nitrogen, hen manure contains a little phosphoric acid and potash.

PRUNING

RED RASPBERRIES

The canes of red raspberries are biennial; that is, they complete their growth in height the first season, bear fruit the second, and then die. The roots are perennial, living for many years, sending up a new crop of canes each year. The canes are of two types, those that develop from buds at the base of the old canes, and those that develop from the roots at a distance from the crown. These latter are known as suckers, and red raspberry varieties vary considerably in the number of suckers they produce. Certain varieties, such as June and Marlboro, sucker rather sparingly, whereas others, such as Cuthbert and Newburgh, produce suckers in great abundance. Unless these suckers are periodically reduced in number the planting soon becomes a dense thicket of little value for fruit production. The fruit buds are formed in the fall on the current season's growth. The following spring they develop into branches and bear fruit.

As soon as the crop is harvested it is customary to remove the fruiting canes. This gives more room for the new growth and destroys many insects in the old canes. Where deep snow causes breakage of the new canes during the winter, the old canes may be left until spring for support. A V-shaped brush hook or long-handled pruning shears are suitable for this pruning.

In the spring after the severe winter weather is past and there is no more danger of winter injury, the fruiting canes are pruned. This pruning consists in cutting back the fruiting cane to a height of 4 to 5 feet, depending on the vigor of the variety. The cutting back should be as light as will permit the cane to remain erect with its load of

fruit. In general, the removal of the relatively weak growth at the tip, which is indicated by the short internodes, will suffice. Branches may be cut back to about 10 inches or 15 buds. Some growers of early varieties who stake or trellis their canes leave this tip growth for the sake of the earlier berries. Even tho these tip berries are rather small, they bring a high price because of their earliness. Failure to remove the tip growth will not materially reduce the size of the berries on the remainder of the cane. On light soils subject to drouth it may be advisable to cut back the canes more severely than on soils abundantly supplied with moisture.

Severe heading back of the canes at the spring pruning has several marked disadvantages. The crop is materially reduced, but the size of the berries is not correspondingly increased. If the height of the fruiting cane is severely reduced the fruiting laterals which develop on the remainder of the cane will be hidden among the new shoots of the current season, thus making harvesting more difficult. The fruit on the laterals of the severely pruned canes will ripen considerably later than that on the moderately pruned canes. Only a few fruiting laterals will develop from the basal buds of red raspberries since many of these lower buds are blind.

At this spring pruning the weak canes should be removed and the remainder thinned to about 6 inches apart. Investigations at the Michigan Experiment Station indicate that not more than 10 canes to 4 feet of hedge row should be left for fruiting.

During the growing season the new shoots should not be headed. Heading them results in the production of weak side shoots and tends to increase the number of suckers, an undesirable condition in a planting devoted exclusively to fruit production. The weak branches are more susceptible to winter injury than the normal unheaded canes.

BLACK AND PURPLE RASPBERRIES

During the summer it is necessary to check the growth of the new shoots of the black and purple raspberries by pinching off the tips. If allowed to grow naturally they make long sprawling canes difficult to manage. To prevent this the new shoots are pinched off when they reach the desired height, usually in June. This throws the growth into the side branches, thus making sturdy, compact, self-supporting bushes. The black raspberry is usually headed at 18 to 24 inches and the purple raspberry about 6 inches higher. If the shoots are headed much higher the bushes tend to become top heavy with the weight of

the fruit the following year and considerable bending over and breakage of canes result. The tip should be pinched off when the shoot reaches the desired height; and since all canes will not reach that height at the same time, it is necessary to go over the field several times during the season.

If the shoots are allowed to grow much above the desired height and are then cut back, this growth will be wasted and the branches will not be as strong as when the shoots are headed promptly. The tips may be pinched off with the fingers or lopped off with a sickle.

As in the case of red raspberries, the old canes of black and purple varieties are generally removed soon after the crop is harvested unless needed for support during the winter. Under certain conditions, such as a dry soil or a dry season, immediate removal of the old canes may conserve some moisture. Conversely if there is an excess of moisture in the soil, leaving the old canes until the end of the season will tend to reduce the excess of water and thus assist in ripening the new wood.

At the spring pruning, which is best done in March or early April after the severe cold weather is past, the weak canes are removed and the fruiting laterals headed back. As a general rule, leave all strong canes, that is, those over ½ inch in diameter, since the average plant can support all the canes of value for fruit production that it produces. If it is desired to reduce the amount of fruiting wood still more, it should be done by shortening the laterals rather than reducing the number of strong canes. It has been shown by investigations at the Michigan Experiment Station that it is profitable to leave a large number of canes to the acre even tho there may be an actual reduction in yield per cane from crowding. Cane yield was not reduced by crowding where the number of canes left did not exceed 5,500 to the acre. In one field on a strong soil it was considered that as many as 8,000 to 9,000 canes to the acre could profitably be left for fruiting. A further advantage of having a large number of canes to the acre is the support they tend to afford each other, thus reducing injuries from high winds.

Other studies at the Michigan Experiment Station indicated that the laterals might be cut back severely at this pruning without materially decreasing the total yield. The total number of berries was reduced, but the size of the berries increased sufficiently so that the yield was about the same as where the laterals were left much longer. Practically all of the buds on a black raspberry cane, except the basal four or five, are potential fruit buds. Short pruning stimulates all the

remaining buds to fruit production, increases the proportion of fruit borne by shoots arising from the main cane, and reduces the proportion borne by shoots arising from the laterals. The best results were obtained by reducing the laterals to a length of 4 to 6 buds. This short pruning also tended to increase the proportion of berries ripening early and reduced the time of harvesting as much as 30 to 40 per cent. Short pruning also tended to minimize the effects of drouth. On very fertile soils with an abundant supply of moisture it may be possible to leave the laterals somewhat longer with beneficial results. At the Ohio Experiment Station laterals were left as long as 8 to 12 buds to good advantage. The laterals on the purple raspberry may be left as long as 10 to 14 inches.

VARIETIES

The selection of varieties is an important factor in the success of the planting. Before deciding which varieties to plant, the grower should have definite information, so far as it is available, concerning the following characteristics of a variety: The plants should be hardy, as winter killing in certain regions may greatly reduce the crop. If the variety is exceptional in other respects it may be profitable to protect it by covering the canes. Considerable variation in yielding ability exists among different sorts, and, other things being equal, the more productive varieties are the more profitable. Some varieties are troubled little by disease; others are severely injured. Control of mosaic by growing escaping and resistant varieties is simpler and more profitable than removing diseased plants and isolating the planting. Growth habit is important in that it may determine whether a variety needs support by trellising or staking. Whether the fruit is hidden in the foliage or borne out in the open and whether the canes are prickly or not determine the ease of picking. Some varieties are more adaptable to certains soils than others. June will probably fail on light sandy soils. The season should be considered in relation to the season of the major part of the crop in the same district, or the markets on which the grower intends to sell his fruit. Thus, June and Ontario will be more profitable in a region growing mainly Latham and Cuthbert which ripen about 10 days later. On the other hand, if June or Ontario are the preponderant varieties in the district, late sorts may be more profitable. Under average conditions an early and a late variety should be grown to lengthen the season. A firm variety like Newburgh will ship much farther and keep longer than a softer sort

like June. If a portion of the crop is to be sold for jam or to the canning factory, select varieties adapted to those purposes. Table quality is not important since most varieties suitable for commercial planting are satisfactory in that respect. Market preferences must also be considered. The Columbian purple variety is popular on certain markets, and the red varieties on others. Cuthbert sells well on some markets where its quality is known and appreciated, but in general its tendency to darken quickly makes it unpopular in competition with the brighter fruit of June and Latham.

Information about varieties may be secured from various sources. Where raspberries are grown to any extent there are always some growers who try new varieties as they appear. These growers should be consulted and their variety collection observed. This Station will on request furnish such information as it has available concerning new or old sorts. Many varieties, including all the standard sorts, recent new varieties, and many seedlings, some of which will eventually be introduced because of superior merit, are being grown at this Station and may be seen by interested fruit growers.

Beware of varieties featured in catalogs from distant regions. However meritorious they may be in the region of their introduction, they should be planted only in limited numbers until they have proved their merit in the grower's district. Too often a variety is planted because a catalog features it in glowing terms with a colored plate. All present-day everbearing varieties are worthless.

A small variety test plat will prove instructive and enable the grower to keep up to date on new sorts. Ordinarily a dozen plants will suffice to indicate whether a variety deserves more extensive trial. It will also make the grower critical of catalog descriptions.

RED RASPBERRIES

Among the numerous red varieties only a few are satisfactory for general commercial culture. June (Fig. 1) and Ontario are the earliest of these and they have replaced Marlboro as the standard early varieties. June ripens at least 10 days earlier than Latham and Cuthbert and consequently deserves a place in every planting to lengthen the season. It ripens about 5 days earlier than Chief and is larger than that variety. Where a premium is paid for earliness, and it usually is on most markets, June and Ontario will be much more profitable than the later sorts. June needs a fertile clay soil, while Ontario in its limited distribution has proved successful on lighter soil.

FIG. 1.—FRUIT OF THE VARIETY JUNE, THE BEST EARLY RED RASPBERRY.

The fruit of Ontario is very similar in size and appearance.

Latham is rapidly replacing Cuthbert as the standard late or main-crop red variety. Its resistance to the mosaics, its vigor, its productivity, and the large, bright red berries make it the best commercial variety of which plants are readily available.

Cuthbert is the standard of quality, and probably will be for many years. It is also the best variety for canning, for jam, and for freezing. However, other varieties are proving more profitable for the fresh fruit trade.

Viking, a new berry of Canadian origin, which ripens about one picking before Cuthbert and Latham, is promising because of its size, attractive appearance, and good quality. In some respects it is superior to Latham. In the Hudson Valley it has suffered severely from winter injury and may require protection in that district. It seems fully hardy in the western and central portions of the State.

Newburgh (Fig. 2) is the most promising new variety from this Station. The characters which make it valuable are its large and unusually firm fruit and ability to escape mosaic infection. Its crop is very heavy, its color is bright, and the quality is good. It ripens 4 or 5 days earlier than Latham and Cuthbert. The plants are of only medium height, and because of the rather long fruiting laterals and the heavy crop may need support. The canes branch freely the first year, but tend to outgrow this habit as they grow older, altho they always branch more than the canes of other red varieties. In the Hudson Valley a few growers have complained that Newburgh is hard to pick. This is true if it is picked before fully ripe, but because of the firmness and dryness of the berry it should be allowed to ripen fully before picking. In New Jersey and New England near the coast it has been subject to considerable winter injury. Newburgh deserves extended commercial trial in all parts of this State as a shipping and main-crop variety. It is not desirable for jam and probably not for canning.

Other varieties which deserve comment but which are not recommended for commercial planting, are the following: Adams 87 is very handsome but too soft for market. Chief is inferior to June and Ontario. Lloyd George is too soft, turns dark, and is of low growth and sprawling habit under most conditions, altho its fruit is very large, handsome, and of excellent quality for the table and for jam. Flaming Giant is Ohta renamed and is worthless for New York State. Herbert is too soft for market purposes, but is excellent for escaping mosaic and does well in gardens. Victory is apparently identical with Cuthbert.

FIG. 2.—FRUIT OF THE NEW VARIETY NEWBURGH, THE MOST PROMISING MID-SEASON VARIETY THAT DESERVES A TRIAL BY ALL GROWERS.

Newburgh escapes infection by the mosaics.

BLACK AND PURPLE RASPBERRIES

Only a few sorts are grown in this State. Plum Farmer a mid-season variety is perhaps, the most widely grown and the most popular variety. Cumberland which is a few days later is increasing in popularity owing to the development of disease-free sources of stock and its greater resistance to red mosaic. Kansas is a good early variety, but is not grown to any extent except in the section on the west shore of Canandaigua Lake. Naples, a new late variety from this Station, is deserving of trial for its large, firm, handsome berries and the vigorous, productive bush. Dundee is handsome and high in quality, but red mosaic spreads rapidly in it. It is slightly more resistant than Cumberland to red mosaic.

Columbian is practically the only purple variety grown in this State. It has been very popular for canning, for jam, and for dessert purposes on certain markets. All Columbian stock has been uniformly affected with red mosaic for several years. Altho it is resistant to red mosaic it should not be grown close to susceptible red or black varieties.

MOSAIC DISEASES AND HOW THEY ARE SPREAD

The aim of studies on plant diseases is to discover practical means of reducing losses in production and thus increase unit area profits. Diseases are often so destructive and the losses so apparent that the grower is well informed concerning them. There are other diseases that are not so directly injurious and the cumulative losses are not easily assigned to the real cause. The two most important diseases of raspberries in New York are of this latter type. They both belong to the group of diseases known as mosaic and they have been named red mosaic and yellow mosaic. There is no way of describing these diseases, defining the losses, and giving suggestions on control without going into some detail. Not all the problems concerning their control have been solved, but there are definite steps which any grower may take to avoid undue loss.

The two diseases, red and yellow mosaic, occur commonly in cultivated and wild raspberries. Some varieties of red raspberries are immune or very resistant to both red and yellow mosaic but unfortunately none of these varieties is suitable for profitable production. Many of the better varieties of red raspberries are susceptible to one or both of these diseases. Most red raspberry varieties are more

damaged by red mosaic than they are by yellow mosaic. A few are more susceptible to yellow mosaic. The susceptible varieties can only be grown successfully when rigid precautions are taken to keep the two mosaics from spreading. There is only one variety that can be recommended that is resistant to both mosaics and that is the Latham. The injury caused in the Latham in most locations and in most seasons is not sufficient to reduce profits seriously. There is another small group of red raspberry varieties that can be recommended because they escape infection. The Herbert is one of these, but it has limited value because of its soft fruit. The other is the new variety Newburgh which promises to be a very satisfactory red raspberry. Varieties that escape infection are more desirable than resistant varieties in avoiding losses from mosaic for they have the added advantage of not harboring and spreading the disease to other varieties. For the reason that varieties differ greatly in susceptibility to the mosaics and that the mosaics spread more rapidly in some than in others, the selection of a variety becomes an important matter.

All varieties of black raspberries are very susceptible to yellow mosaic. The purple Columbian is equally susceptible to yellow mosaic. Fortunately, yellow mosaic does not spread rapidly in black and purple raspberries and the losses are not great. Wild or cultivated red raspberries may often contain large amounts of yellow mosaic and may be the cause of its spread into black and purple raspberries. The black varieties that are commonly grown are susceptible to red mosaic and it spreads more rapidly in black varieties than it does in most red varieties. The Cumberland is more resistant to red mosaic than Plum Farmer. The degree of injury caused by red mosaic in black raspberries is subject to considerable variation and will be more fully explained later.

Both of the raspberry mosaic diseases are contagious. The cause of the mosaic diseases is a parasite in the plant which is too small to be seen by the eye or with the aid of a microscope. Millions of these very small parasites invade all parts of the raspberry plant and cause certain injuries. Since the varieties of raspberries are propagated by transplanting portions of the mother plant which have developed a new root system, the new plants are diseased if the mother plant is diseased. This makes the selection of disease-free plantings from which raspberry nursery stock is obtained an important matter as the first step in control. To take plants from a field containing diseased plants results in starting off with about the same amount of disease in

the new planting. Spread within the planting can be expected to double or triple the number of diseased plants in the 2 years before the first full crop is harvested.

The mosaics are spread to healthy plants in only one way; they are carried by the large species of aphid that occurs commonly on all kinds of raspberries. This aphid does not cause any injury itself and it rarely occurs in large enough numbers to attract attention. The most favorable time for it to become abundant is in June. Strong growth of the new canes, shading, abundant soil moisture, and absence of frequent rain periods lead to large numbers of these aphids on the leaves near the tips of the canes. These aphids are easily shaken to the ground during rains and a heavy mortality results. If the growth of the new canes is not rapid the colonies become smaller and in midsummer they are found in scattering numbers only under the most favorable conditions. Some varieties are more favorable food plants and on these larger numbers of the aphids will be found. Winged individuals occur more frequently when large numbers crowd the leaves.

The two mosaics are transferred from diseased to healthy plants when these aphids move from plant to plant. There would be little movement and consequently much slower spread of the mosaics if the aphids were not disturbed. Rains, winds, cultivating, pruning, and picking berries all result in shaking the aphids to the ground. If they have wings they will begin flight; if not winged they crawl about, searching a raspberry plant. They are extremely active in this search and can exist for many hours and cover considerable distances. When these facts are recognized it is not surprising that the amount of mosaic increases rapidly in a planting if numerous diseased plants are present within the planting or in the vicinity.

The spread of mosaic from diseased cultivated or wild raspberries into healthy plantings is dependent largely on wind carrying the aphids. The rate at which new infections show in the healthy planting will depend somewhat on distance from diseased plants, the abundance of the diseased plants, the variety in each case, and weather conditions. Much slower spread will result in some varieties than others when they are planted side by side. The reason for this is unknown but reflects some varietal character in relation to aphid feeding that causes it to escape infection even when aphids arrive on it from diseased plants. Varieties may be rated on their ability to escape mosaic infection and in some the trait is so pronounced that they remain healthy for several years alongside diseased plants. The

two red varieties, Herbert and Newburgh, are examples. At times varieties which are relatively slow to become affected by mosaic in one locality may apparently lose this property in another. This is due more to the relative abundance of the carrier aphid in the two localities than any other factor. The more abundant and closer the diseased plants are to a healthy planting, the higher the rate of spread will be, due to larger numbers of aphids arriving in the planting. The varieties that harbor larger populations of the aphid cause higher rates of spread over the same distance. Red raspberries usually show a larger number of aphids than occur on purple or black raspberries and therefore are responsible for higher rates of spread into new healthy plantings. Wind is a variable agent in carrying the aphids from one planting to another. Mosaic is spread over a considerable area around a diseased planting by this means and no limits can be given for absolute safety.

Direction of the prevailing wind, presence of windbreaks, the variety, the area covered, and the vigor of the diseased wild or cultivated sources of mosaic spread are all factors which determine the distance and rate of spread into new plantings. No rules can be given, but distances of several hundred feet are necessary for protection under some conditions.

EFFECT OF MOSAICS ON GROWTH OF RED RASPBERRIES

The vigor of the fruiting shoot and the quantity and quality of the fruit, are dependent on the size and vigor of the fruiting cane. Cultural practises and adaptibility of the variety to soil and weather are the principal factors that regulate size and vigor of the new green canes which the following spring develop the fruiting shoots. If the green cane has been dwarfed in diameter, height, node length, leaf size, and chlorophyll efficiency, the vigor of the fruiting shoot is materially lowered. As the fruiting shoots begin development very early in the spring it is natural that the first leaves are often injured by low temperatures. Actual killing of the leaves, clearing of the veins, crumpling, and a small pattern mottling are some of the low temperature effects. The small size of these leaves normally makes them of little importance to the plant. Low temperature injuries to the leaves during the development of the basal portion of the fruiting shoots often make mosaic diagnosis in these leaves difficult or impossible. The variety June more frequently than others shows marked weather injury confusable with mosaic effects.

The average season at Geneva leads to a definite expression of yellow mosaic (Fig. 3) in the leaves of the mid-portion of the fruiting shoot. In the seasons favorable for maximum yellow mosaic effects, the leaves are reduced to one-half or less of their normal size and are largely yellow with little green remaining. The tendency to curl or blister is largely lacking and serves to differentiate yellow mosaic from red mosaic in these leaves. In seasons when yellow mosaic is expressed to the maximum degree in the fruiting shoot leaves, gradations of susceptibility between varieties is less apparent. In seasons when yellow mosaic symptoms are suppressed to the vanishing point, gradations in yellow mosaic susceptibility are likewise not clearly differentiated. Observations have shown that weather and soil conditions causing slow growth of the fruiting shoots lead to pronounced symptoms (increased susceptibility) and conditions causing rapid fruiting shoot development lead to suppressed symptoms (decreased susceptibility). Low average temperatures and slow growth as compared with high average temperatures and rapid growth at times seem to account for the seasonal differences in susceptibility to yellow mosaic. As in the case of the definite relations of growth rate to susceptibility of black varieties to red mosaic, the correlation between the susceptibility of the fruiting shoots of red varieties to yellow mosaic and their growth rate seems to be more general and not dependent alone on the single factor of temperature.

There can be no fixed rating for the susceptibility of red varieties to yellow mosaic because of the wide difference in susceptibility of a given variety in the same locality from season to season. The effect on the fruiting shoots of the three varieties Latham, Viking, and June may be taken as examples. For a fixed location, such as Geneva, their relative susceptibility is easily demonstrated every year. Latham, being the most resistant, shows none or slight signs of mottling; Viking, intermediate, shows slight to pronounced symptoms in one or several leaves; and June, being the most susceptible, shows pronounced symptoms in one or several leaves every year. The degree of susceptibility in a given variety is also indicated definitely in the abruptness of change in strength of symptoms. Thus, the more resistant a variety, the fewer the number of leaves that show symptoms. In Latham one leaf may show slight mottling, the next distinct mottling, and the next very slight mottling, while all the other leaves may be free from mottling. For the same stage of growth a susceptible variety, such as June, will show symptoms in four or five

Photo by W. R. Fisher

FIG. 3.—EFFECT OF RED AND YELLOW MOSAIC AS SHOWN IN THE LEAVES OF RED VARIETIES.

The pictures show the typical effects of red mosaic (left) and of yellow mosaic (right). The distinction between the effects of these two mosaics is often not clearly defined. For red mosaic, the typical effect is large or small areas of lighter green or whitish, rarely yellowish, mixed with irregular dark green slightly or distinctly blistered areas. For yellow mosaic, the typical effect is large or small yellowish green to distinctly yellow areas mixed with normal green areas not blistered except very slightly when islands of green are surrounded by extensive yellow areas.

leaves, slight symptoms being formed at the extremes that showed no symptoms in the resistant variety. This fact is only an indication that critical optimum conditions must obtain for resistant varieties to develop symptoms and then they are shown mildly, while in susceptible varieties less critical conditions are necessary for slight symptoms and when optimum conditions are reached pronounced symptoms develop.

The relative strength of symptoms of yellow mosaic shown on fruiting shoots and new canes cannot be directly compared for they develop at different times, but in general it may be said that stronger symptoms and more injury occur to the fruiting shoots than to the new canes in the same variety. This is probably due to the fact that the fruiting shoots develop at a time when a slower growth rate is normal. Also a few leaves reduced in size and chlorophyll content are more serious factors on the fruiting shoot than a few leaves equally affected on a new cane, for in most varieties during midsummer the new canes develop unaffected leaves and make normal growth. Thus it happens that a grower may be skeptical of the importance of yellow mosaic when judged by the slight symptoms shown only in the basal leaves of the new canes but is much concerned by the full effects of yellow mosaic as shown by fruiting shoot foliage and the crop. This was demonstrated by the variety Perfection in the Hudson Valley before that variety was abandoned. Each season in the well-cared-for plantings the new canes grew to normal height with only slight injury to the leaves, but the injury to the fruiting shoots was severe enough to lower the quantity and quality of fruit to the point that no profit was forthcoming.

The important fact concerning yellow mosaic in red varieties is that the crop is liable to suffer both from the yield and quality standpoint. The new cane vigor is usually not much lowered, but when weather conditions and the growth rate of the fruiting shoots are favorable for maximum injury, the leaves are reduced in size and lack much of the green chlorophyll that is necessary for fruit production. The two most important changes that result in the fruit due to the mosaic diseases are that the flavor is lost and the fruit crumbles easily. The crumbling character results in the pickers crushing the berries, the pack is more likely to mold due to the crushed berries, and the package arrives on the markets very poor in appearance due to settling. The more severe the mosaic effects are in the fruiting shoot leaves for that season, the more likely are the losses from crumbling

to be serious. There is also a direct and important connection between mosaic injury to the leaves of the fruiting shoot and losses from drought and sun scorch. The mosaic-injured leaves are more susceptible to dry weather effects and thus the size and number of berries set are affected and the crop may be worthless after the first or second picking.

The strength of leaf mottling caused by red mosaic (Fig. 3) in red varieties is a function of two factors, varietal susceptibility and rate of growth. Certain varieties, such as Herbert, develop extreme symptoms of red mosaic; the leaves being almost devoid of green (chlorophyll) and markedly reduced in size. In such varieties the growth of the new canes is dwarfed severely. In less susceptible varieties, such as Cuthbert, the more vigorous and uninterrupted the growth of the new canes, the more pronounced are the leaf symptoms, but in such a variety a considerable area of the leaves contains chlorophyll which is even intensified in the dark green blistered areas. Other factors being conducive to vigorous growth, the leaf changes, tho severe, may not result in dwarfing. Furthermore, fruiting shoots on such plants may produce a fair crop according to the balance between the effect of the severe mottling and the vigor due to soil conditions and climate. In plantings of moderate vigor less extreme leaf symptoms often have a more destructive effect on the yield and quality of fruit and the new cane growth will likely be gradually reduced to a definitely unproductive stage (Fig. 4). This relation between vigor and strength of symptoms of red mosaic in red varieties may be followed to the other extreme. In cases where very poor growth is made, susceptible varieties show reduced symptoms. The tendency to define sharply the light green or yellowish areas from the dark green blistered areas is largely lost and the symptoms are then confused with those of yellow mosaic.

From observation it is believed that red mosaic is largely undetectable in escaped plants and in many wild seedlings where cane growth and the leaves are reduced to very small size. One may assume from these observations that leaf size is the primary function determining the strength of symptoms shown in susceptible varieties. That is, if the leaves grow to large size rapidly, very strong symptoms are developed, but if the vigor of the plant is such that the leaves are small and develop slowly, then the symptoms are reduced to the vanishing point. This assumption of the relation between leaf size and rate of growth of the leaves to strength of symptoms is borne out

in resistant varieties, such as Latham, where very vigorous growth and large leaves show a strength of symptoms of red mosaic which

FIG. 4.—DWARFING OF NEW CANES OF A SUSCEPTIBLE RED VARIETY CAUSED BY RED MOSAIC.

The new canes are often dwarfed to one-half the height of healthy canes. The leaves are small and mottled. The berries borne on the fruiting shoots of such canes are small, they crumble easily and lack the raspberry flavor.

bring out the blistering effect. In plantings of moderately vigorous growth sufficient for profitable yields red mosaic symptoms in Latham are rarely brought out to this stage and usually are confusable with yellow mosaic in this variety.

In general, increased vigor in red raspberries tends to decrease the injury caused by both mosaics. For yellow mosaic the relation is very definite and moderate to high vigor in most varieties reduces the injury to the new canes to a negligible amount. Since the principal injury by yellow mosaic is caused by its activities in the fruiting shoots, the injury to the crop may be severe (according to seasonal and climatic factors) even tho injury up to that point has been circumvented by maintaining vigor. For this reason varieties susceptible to yellow mosaic should be avoided in localities which, in the average season favor a full expression of yellow mosaic in the fruiting shoots. The injury to the new canes caused by red mosaic in most red raspberry varieties may be decreased by maintaining maximum vigor. The degree of vigor necessary to accomplish this is much more difficult to obtain for red mosaic than it is for yellow mosaic, and unless soil and cultural conditions are ideal it is doubtful if other measures to increase vigor will pay returns in counter-balancing the red mosaic injury. Furthermore, in most varieties susceptible to red mosaic the fruiting shoots are injured to the degree that losses in yields and quality are serious in spite of the apparent maintenance of vigor in the new canes. This effect on the fruit is more independent of seasonal conditions and locality than it is in the case of yellow mosaic. Yields in two parts of a very vigorous Cuthbert planting were obtained which showed that in the portion containing a high percentage of red mosaic with little dwarfing of the canes or reduction in leaf size, the yield was only about one-half that obtained in the portion where no affected plants occurred. When it is remembered that the quality of the fruit is also reduced on the diseased plants, it can easily be understood why it is not good economy to attempt to circumvent red mosaic injury by maintaining high vigor. Loss of the characteristic flavor, small size, and tendency to crumble are the principal effects on the berries.

EFFECT OF MOSAICS ON GROWTH OF BLACK RASPBERRIES

Red mosaic causes two kinds of reactions in black raspberries which could easily pass for different diseases. These two kinds of effects may

be briefly described as mottling of the leaves of the fruiting shoots and new canes (Fig. 5) and dying of the tips of the new canes (Fig. 6). The plant may show either or both of these types of symptoms at various stages of growth and at other times normal growth is made free from any effect. This fact indicates that certain conditions in the environment or in the plant itself determine whether symptoms will show or not and whether the symptoms will be strongly or weakly expressed. The symptoms originate in the growing tip of the fruiting shoot or new canes and the parts being formed at any one time express the strength of symptoms as regulated by conditions at that time. The principal factor that regulates the strength of symptoms is not definitely known but is believed to be something closely correlated with rate of growth. Temperature has been suggested as a single factor, but the assumption that lower temperatures bring out stronger mottling of the leaves than higher temperatures does not account fully for the changes that occur under field conditions.

In early summer when conditions favor rapid succulent growth of the new canes, dying of the cane tips often occurs as the maximum expression of red mosaic. In the first season in a new planting the canes grow vigorously into long trailing vines with little branching. In their early growth the tips of these new canes are very susceptible, and if the plant is infected by an aphid arriving from a plant affected by red mosaic, the tip dies (Fig. 6). The more vigorous the cane growth, the more sudden is the death of the tip and the more likely it is that the plant will be killed in its entirety. Older plants making vigorous growth are very susceptible at the time the new canes are high enough to be pinched back to throw laterals. If infected at this season the cane tip or the short rapidly growing laterals are often killed. The stem and tip leaves turn blue quickly, become brittle, and die (Fig. 7, upper). All the lateral tips of the plant may react in this way or some may escape. According to the degree of injury to the new canes, the plant may pass into a condition of rapid decline or it may be only moderately reduced in vigor. The next season after infection these different degrees of decline are apparent. The extreme effect is the death of entire fruiting canes or severely dwarfed fruiting shoots with small, dark green, curled leaves (Fig. 8). Such shoots bear small seedy berries on short stems which cause a crowding of the berries into a compact head. In less severe cases the fruiting shoots may be almost normal except for a reduction in size of the leaves and a mottling of yellow or light green areas, large or small in size (Fig. 9).

Photo by W. R. Fisher

FIG. 5.—EFFECT OF RED MOSAIC ON LEAVES OF BLACK VARIETIES.

The two leaves pictured were adjacent on the new cane. The leaves above and below this point were free of any mottling. Extensive mottling is accompanied by dwarfing in size of the leaf. Similar effects are caused in the leaves on the fruiting shoots of black varieties, and on such shoots with several leaves dwarfed and mottled, the fruit is seedy and of poor quality.

Photo by W. R. Fisher

FIG. 6.—EFFECT OF RED MOSAIC ON NEW CANES OF BLACK VARIETIES DURING THE FIRST SEASON AFTER PLANTING.

During midsummer rapid vigorous growth causes the tips to be very susceptible and they are killed soon after infection. The picture on the left shows the tip bending over. All growth has ceased, and the tip of the cane is blue or black and it soon dies. Later in the fall the effect is not so sudden. The picture on the right shows several dwarfed leaves with short blue petioles preceding the death of the tip.

Photo by W. R. Fisher

FIG. 7.—EFFECT OF RED MOSAIC ON TIPS OF NEW CANE LATERALS OF A SUSCEPTIBLE BLACK VARIETY.

Tip portions of two laterals from the same cane. Upper picture shows killing of the tip preceded by dwarfing of two leaves; typical of the effect of red mosaic on vigorous new canes. The lower picture shows one lateral tip escaping the extreme effect; several leaves were dwarfed and the tip then grew on normally.

FIG. 8.—EFFECT OF RED MOSAIC ON FRUITING SHOOTS OF SUSCEPTIBLE BLACK RASPBERRIES.

The pictures show a healthy and a diseased fruiting cane of the same variety. Some varieties show this marked effect on the fruiting shoots soon after infection; others develop this effect only after the fruiting cane is severely injured by the tip killing effect the season previous. Resistant varieties rarely show this effect.

Photo by W. R. Fisher

FIG. 9.—EFFECT OF RED MOSAIC ON THE LEAVES OF BLACK AND PURPLE RASPBERRIES.

Leaves on the fruiting shoots or new canes may show variable degrees of mottling. Slight mottling consists in very small, irregularly placed, lighter green areas in an otherwise normal leaf (upper left). Or the small light green areas may merge, forming large irregular patches involving one-half or more of the area (lower left). Or the leaves may show large and small light green areas surrounding normal green blistered areas (upper right). The lower right picture shows the combined effect of red and yellow mosaic as developed in the Columbian.

When the light-colored areas in the leaf are large and numerous, the green tissue between is slightly blistered. The fruit on such shoots is more seriously affected than the appearance of the fruiting shoots would indicate.

FIG. 10.—EFFECT OF RED MOSAIC ON NEW CANES OF RESISTANT VARIETIES.

Two new cane tips are shown; the one on the right has been arrested in growth forming a rosette and the one on the left after developing a few small leaves grew on normally. Mottling is usually shown in the dwarfed leaves of such canes.

Resistant varieties which show little tendency for the new cane tips to die back slowly decline in vigor until they become unprofitable. Susceptible varieties show great variability in rate of decline, since growth conditions largely determine the amount of dying of the tips of the new canes. All the diseased plants in an average season will show some indication of the killing effect of the mosaic on the growing cane tips. In many plants, especially under favorable growing conditions, the extreme effect will occur and the plants will rapidly decline. In others, only moderately vigorous, the tips may at some stage of growth start to die and then recover and grow on the remainder of the season.

In either the case of a resistant variety which rarely shows dying of the tips or a susceptible variety in which the dying of the tips is suppressed because of lack of vigor, various degrees of effect on the cane tips may occur at some stage in their growth (Fig. 10). The effect may be so limited that it will escape notice. Only a single leaf on each lateral may be affected. This leaf will be smaller than normal and the leaf stem short and often mottled with blue (Fig. 7, lower). Or this effect may be shown in two or three leaves together with a distortion of the cane and some blue markings. The new cane laterals which show these suppressed effects resume practically normal growth, altho there seems to be a moderate dwarfing effect for they rarely show any subsequent recurrence of such symptoms

that season. Often a leaf or two just preceding or succeeding the dwarfed leaves with blue petioles will be mottled with light green areas, showing that this effect is due to similar conditions.

The complete picture of red mosaic in black raspberries seems to be that as conditions stimulate more vigorous growth a stage is reached where mottling is expressed, if the growth rate is increased the extreme effect of killing the new cane tips is possible. In fields of low vigor, especially in resistant varieties, definite symptoms may be largely suppressed, while fields of susceptible varieties growing vigorously may show large losses of plants due to the extreme symptoms of cane tip dying and the resulting subsequent dwarfing which occurs after such a serious set-back. Due to the regulation of the reaction of the black raspberry to red mosaic by fluctuating growth conditions, diseased plants which have escaped serious injury for one or two seasons may suddenly be severely affected.

The balance between vigor and susceptibility to serious injury cannot be used to reduce losses. In most varieties, keeping the plants in sufficiently low vigor to escape the full effects of red mosaic results in low yields and poor quality of fruit. It might be advisable to handle a resistant variety, such as Cumberland, in moderate vigor rather than high vigor if it contains a high percentage of red mosaic but even this method has its limitations because the fruit characters are more seriously affected than is the cane growth and losses will increase.

For high yields and good quality of fruit, free from the crumbling effect, red mosaic must be kept from spreading in black raspberries. Where the rate of spread is difficult to reduce to a minimum by proper isolation, attempts to obtain high yields by maintaining high vigor will undoubtedly be disappointing for the planting will be short-lived. The comparison of such a planting with an existing non-vigorous planting containing a high percentage of affected plants might not seem to justify mosaic control. However, the comparison should be made on a different basis. The yields and quality of fruit obtained from fields in which the destructive symptoms of red mosaic are suppressed result in minimum profits. Given conditions to insure protection from rapid red mosaic invasion and spread, vigor can be maintained which will enlarge the possibilities of profits for reasons of the higher yields and better quality. Attempts to increase unit profits by selecting a suitable site and soil type and maintaining high vigor to insure maximum yields and quality are dependent for success on the control of red mosaic. This statement is so true in New York

that red mosaic control should be given first consideration ahead of any other factor if maximum profits are to be obtained.

Yellow mosaic, altho more prevalent in red varieties in New York than is red mosaic, is not an important disease in black varieties. When precautions are taken to insure low red mosaic losses, yellow mosaic will be reduced to a vanishing point. All black varieties are very susceptible to yellow mosaic, but it does not spread rapidly. The affected plants irrespective of vigor or seasonal conditions are seriously injured to the point that they contribute no fruit worth picking. The plants are quickly dwarfed and the leaves are small and distinctly yellow (Fig. 9). From the first the symptoms are clearly evident and by the following year the plants are dwarfed and are easily recognized as different from plants affected by red mosaic or any other disease.

REDUCING LOSSES FROM MOSAICS BY USING RESISTANT OR MOSAIC-ESCAPING VARIETIES

Briefly, there are two methods of avoiding losses from the mosaics, grow a variety that is either resistant or mosaic-escaping, or obtain a mosaic-free strain of the susceptible variety that is desired and keep the mosaics from spreading. The former method is simpler since no additional measures or precautions are necessary. From observation in western and central New York, the red variety Latham exhibits sufficient resistance to the mosaics to maintain the yield. The mosaics reduce the vigor of this variety to some extent and also the berries from diseased bushes tend to crumble, but the accumulation of these losses are only slowly evident if the planting is started with stock relatively free of diseased plants. This is difficult to secure in a resistant variety, since the symptoms do not show plainly at all seasons and stock certified as low in mosaic content may actually contain a large number of diseased plants. At Geneva the mosaics do not spread rapidly in Latham, but this may vary considerably for other districts. Also, the degree of resistance of Latham is somewhat determined by weather conditions at the time the fruiting shoots are growing. Conditions favorable for the maximum expression of injury to the fruiting shoot leaves may cause reduction in crop and crumbly berries. This seasonal effect is temporary and the crop on the following season's canes may be little injured. For the Hudson Valley district Latham is likely to be less resistant than in western New York.

Varieties that show a high degree of the mosaic-escaping property furnish an ideal method of control. Herbert is such a variety, but it has features which disqualify it for other than home or local use.

The new variety Newburgh has been tested at Geneva and elsewhere under conditions that seem to have given ample chance to show its mosaic-escaping property. Up to the present time red mosaic has been found in only one planting of Newburgh and in this planting very exceptional conditions prevailed for rapid spread of red mosaic from wild red raspberries. In other plantings where this variety has grown alongside diseased cultivated red raspberries for periods up to 4 years no plants have shown infection. It seems, therefore, that Newburgh can be depended upon to escape mosaic infection, and because of its valuable horticultural characters it should become a widely accepted variety.

PREVENTING RAPID SPREAD OF MOSAIC INTO SUSCEPTIBLE VARIETIES

Until a wider choice of resistant and mosaic-escaping varieties can be developed, many growers will desire to grow a number of the susceptible varieties because of their otherwise desirable horticultural characters. June and Ontario are early varieties which, with certain precautions are not difficult to grow free of mosaic. This has been demonstrated by the fact that many growers maintain their plantings practically free of diseased plants. The same is true for many of the older varieties, such as Cuthbert, and others where they may be desired. Red and yellow mosaic do not spread very rapidly in red varieties in central New York, but higher rates of spread seem to be the rule in western and eastern districts in the State where raspberries have been grown extensively for long periods. This may be due to the concentration of the cultivated fields and to the large population of escaped raspberries in wastelands.

According to the experience in the district, isolation from other cultivated and wild raspberries becomes a local problem. In general, mosaic-free red varieties should not be planted closer than 200 or 300 feet to possible sources of mosaic spread. Wind direction, wind breaks, size of area covered by the diseased plants, their vigor, and the probable aphid population are all factors that may modify the distance that is required to assure freedom from rapid spread. Where prevailing winds are common mosaic spread is more likely if the direction is such that winds will carry aphids directly from the source to

the mosaic-free planting. A vigorous planting of considerable size containing a large number of affected plants will naturally be a more dangerous source of spread than a few weakly growing plants in an abandoned planting or in a pasture. Wild plants along border lands, fence rows, and at margins of woodlands often are diseased and may support high populations of the aphids that carry the mosaics. A few such plants may be very important sources of infection.

In addition to choosing a location at a distance from sources of spread or freeing the required zone of all other raspberries, the planting itself must be inspected and all diseased or suspicious plants found must be promptly removed. To accomplish this the grower must learn to recognize the first indications that are shown in the diseased plant. These will vary with the season and variety and can only be learned by experience. The planting during its first season should be examined for diseased plants that may have come with the stock as soon as the new cane growth is about a foot in height. One or two later inspections in late summer and early fall should locate any new infections. The principal inspections the second year should be made at the time the fruiting shoots are fully developed and again when the new canes are 1 or 2 feet tall. One or two later inspections may be made in the autumn, but by this time the root systems in red varieties will be so extensive that complete removal will be difficult.

The most accurate and frequent inspection to locate diseased plants as soon after they show the first symptoms must be supplemented with considerable care in removing the plants or the benefits may be of doubtful value. Each diseased plant is a source of spread and the aphids on it are the only means of spread to healthy plants. Digging the plant is sure to dislodge aphids from it if they are abundant. The amount of danger involved in digging and handling the diseased plants is less just after protracted rains. At certain seasons when the aphid population is high (June particularly) and when no rains have occurred for several days, removing diseased plants may cause more spread than if they are left until a rain occurs. The torch method of scorching the foliage before digging the bushes is the safest method to use but requires the purchase of the equipment and extra labor. First season plants are easily pulled and there is not much chance of spreading the aphids if the pulled plants are placed in a container for removal from the planting. Digging the larger plants must be done in a way least likely to dislodge the aphids and the plants should be immediately carried out overhead. If the planting

is thus carefully freed of such diseased plants as may occur in its first and second season and if it is located at a distance from sources of spread, the mosaics should not spread rapidly enough in the next two or three seasons to cause much damage. Removing diseased plants after the second season is not recommended because three plants would have to be removed for each one found diseased. Removing the adjacent plants is necessary in the case of red raspberries in order to remove the roots and in blacks and purples to rid the planting of the adjacent plants which are likely to be affected. This procedure would often reduce yields more than would result from leaving the plants in the field.

All that has been stated above regarding isolation from possible sources of spread is much more important for protecting black varieties from the mosaics than it is for red varieties. The distances from possible sources must be greater, at least several hundred feet, and under the most favorable locations some spread may be expected. Red varieties and wild or escaped red raspberries are the most dangerous sources of spread of both mosaics into black raspberries. In this connection cultivated plantings of resistant red varieties, such as the Latham, may harbor an unsuspected amount of the mosaics.

The purple hybrid variety Columbian is frequently grown in some sections and it is a source of red mosaic spread into other varieties. The Columbian variety is resistant to red mosaic and all of the stock is affected. Altho red mosaic does not seem to be spread as rapidly from Columbian as from some other sources, it must always be considered when locating new plantings, particularly of black varieties. The Columbian is susceptible to yellow mosaic, but it does not spread rapidly in this variety. The plants are decidedly dwarfed and easily recognized (Fig. 9).

If the stock was relatively mosaic-free (under 1 or 2 per cent) and if a suitable site reasonably free of possible sources of spread was chosen, and provided the diseased plants were sought out frequently and removed in a manner not likely to scatter the aphids, the grower's expectation should be a stand of healthy plants at the end of the second year from which not more than 1 plant in 20 has been removed because of mosaic spread. If all of these factors contributing to mosaic control have been favorable to that extent, the planting enters its first full bearing year with the prospect of several years of sustained yield, so far as mosaic losses are concerned.

The amount of mosaic that has appeared in the planting from outside sources of invasion, during the second season particularly, is an index of the rate of spread that may be expected in the future. If this spread has been considerable (over 5 per cent), additional protection would be advisable by searching for the source and eliminating it if possible. In plantings that show no serious mistake in the selection of planting stock or the location for the planting, the annual increase of mosaic after the second year should not be rapid. Particularly in the case of resistant varieties and to some extent in susceptible varieties, the yield of the affected plants is only partially reduced. But as the planting becomes older, the accumulative effect of increasing numbers of affected plants and their rate of decline in vigor will eventually determine the time that the planting should be abandoned. Handling a planting in this manner to obtain the longest period possible for profitable yields results in a percentage of affected plants too high for nursery stock production. This, together with the fact that only those growers who because of favorable location and directed effort will be able to raise pedigreed, high-grade, mosaic-free nursery stock, indicates that an increasing demand for such stock will mean a separation between growing raspberries for fruit and nursery stock.

The growing of suitable nursery stock should become a specialty that cannot be carried on near fruiting areas with the yearly increasing amounts of the mosaics and other similar diseases in the older plantings. The most promising method of raising mosaic-free raspberry nursery stock of black varieties would seem to be an annual turn over from dormant sets to rooted tips. Such a procedure in a well-isolated area takes full advantage of the small amount of foliage to receive aphids, particularly in June.

LESS PREVALENT DISEASES SIMILAR TO THE MOSAICS

Two diseases known as **severe streak** and **mild streak** occur in black raspberries in New York. They are not prevalent but may become important sources of loss in certain plantings. Severe streak causes more injury to the plant than mild streak, and the affected plants rapidly decline in vigor and productiveness. The symptoms of the two streak diseases are similar except for the degree of injury. Mild streak does not affect the vigor of the plant markedly, but it causes dry, seedy berries and for this reason losses are greater than the appearance of the plants would indicate. The principal symptoms

of each are shown in the curling downward of the leaves and blue streaks on the new canes. In severe streak the curling of the leaves, together with a large blotch type of mottling and dwarfing of the new canes, causes a conspicuously diseased plant. In mild streak only slight foliage curling and little or no dwarfing make the identification of the affected plants difficult. In both diseases a sharp bending downward of the tips of the unfolding leaves of the new cane laterals furnishes an early symptom for recognizing affected plants. This and the more general symptoms are best developed in mid-summer. While the exact carrier insect of these streak diseases is not known, they are spread in much the same manner as the mosaics and the control measures are the same; that is, the use of streak-free stock and isolation. There are no varieties of black raspberries that are sufficiently resistant or streak-escaping to depend upon as means of control.

Two **leaf curl** diseases that cannot be distinguished one from the other occur occasionally in red varieties, particularly Cuthbert, and one of these leaf curls occurs rarely in black varieties. The plants affected by leaf curl are severely stunted soon after infection and the fruit is worthless, being small, dry, and seedy. The leaves curl tightly and are darker green than normally. The new canes are severely dwarfed. The symptoms are visible as soon as the plants put out new foliage in the spring. The leaf curl disease spreads by being carried by a small aphid which is very commonly found on all kinds of raspberries. It is a different species than the one that carries the mosaics. Removing the diseased plants as early in the season as possible will readily eliminate this disease in New York because it spreads so slowly. Since curl is found in very few plantings or wild plants, no particular precautions regarding isolation of new plantings is necessary beyond the requirements for mosaic control.

OTHER DISEASES OCCASIONALLY CAUSING REDUCTION IN VIGOR AND STAND

Anthracnose, or **cane spot,** is the most important of the fungus diseases of raspberries. It occurs most destructively in black varieties and less so in purple varieties. Red raspberries are rarely affected, but many growers are confused by the large purple spots of the spur-blight fungus on the new canes of red raspberries and believe this to be anthracnose. In black and purple raspberries anthracnose

may cause serious losses in a season's crop. Often this disease is prevalent due to cultural mistakes. Weeds, grass, and an unregulated thick stand of canes lead to rapid spread of the fungus causing the cane spots. Clean cultivation thruout the time the new canes are growing minimizes the chances of this disease becoming destructive. In general, vigor diminishes the effect that the same amount of infection would have on weak slow-growing canes. The fungus spreads rapidly under favorable conditions of frequent rain periods at the time when the new canes are making their first foot of growth. Numerous cane spots initiated at this time result in weakening or even death of the cane. With such a start and frequent rains later, cane spots may result from the rapid spread of the fungus on the new cane laterals and small brownish spots on the leaves of the new canes and fruiting shoots also may develop. Frequent spraying with the ordinary fungicides containing either copper or sulfur is not recommended for raspberries because injury by these materials often will out-weigh the benefits that could be gained in reducing the amount of anthracnose. Partial control may be secured by early applications of lime-sulfur at the time when the new growth is emerging from the buds. The lime-sulfur spray at this time should be used at the winter strength of about 1 part of the concentrated lime-sulfur solution to 10 parts of water. This spray is believed to reduce considerably the amount of anthracnose that develops on the bases of the new canes and is worthwhile if anthracnose is to be favored by weather conditions that season. Since that is an unknown factor spraying for anthracnose control must be determined by past experience and on an insurance basis. Covering thoroly all parts of the fruiting canes is essential to obtaining the best results from the spray. A very decided step in reducing anthracnose losses can be taken at planting time if the "handles" on the sets are removed. The "handles" are the tips of the canes that were buried to produce new plants and anthracnose spots often exist on the "handles" ready to spread the fungus to the new green canes.

Rust, or "**yellows**", is a fungus disease that involves the entire plant and after the fungus becomes established it exists in the plant from year to year, growing into the new canes from the crown. The yellow dust that is shed from the under surfaces of the leaves spreads the fungus to healthy plants. The disease causes dwarfing, lack of prickles on the new canes, and a large increase in the number of new canes. All affected plants should be removed very early in the spring

before the yellow dust appears on the leaves. Rust is a common disease in central New York, but it is not prevalent in other sections.

Wilt is a disease that may occur in new plantings of black or red raspberries, according to whether or not the wilt fungus is present in the soil. Crops preceding the raspberries, such as tomatoes, potatoes, eggplant, and others of this group, often infest the soil with the wilt fungus. If only a small amount of wilt shows in the new raspberry planting it need not be assumed that it will be a failure, for usually the trouble disappears rapidly and affected plants may recover. A broad blue stripe develops on the side of the new canes and the leaves are shed from the base upward. Such canes usually die.

Spur-blight occurs in red varieties frequently and may cause considerable loss. The spread of the fungus causing this disease is favored by a dense stand of canes in wide rows with abundant foliage. From observation it is rare that spur-blight assumes serious proportions except when favored by dense growth which prevents rapid drying of the canes after rains. Moderate amounts of infection which often show in plantings are much less injurious than they appear and often cause needless alarm. The distinct blue oval spots encircling the buds at the bases of the new canes usually involve only the outer thin tissue of the epidermis and this is soon replaced by corky tissues beneath in the normal changes in the fall. The buds are often invaded and produce no fruiting shoots the next season. If cane growth is vigorous this loss is not serious. Spraying measures to combat the spread of spur-blight are of doubtful value. There is danger of foliage injuries from either copper or sulfur sprays. Since the need for artificial means of control is favored by dense growth, the more direct method of correcting these conditions is advisable.

Root-galls on raspberries are caused by the same parasite that causes root-gall and crown-gall of many kinds of plants. This disease may occur on wild plants and often is present without the grower's knowledge. Raspberries are very susceptible to it and it may show up in a raspberry planting even tho no root-gall was present on the stock when it was planted. This disease is more prevalent in some parts of the country than others. It rarely becomes damaging in raspberry plantings in New York. State laws regarding freedom of nursery stock from diseases and insects have always recognized root-gall as one of the diseases that must not be present in the stock when offered for sale. Most states do not make inspections of stock

at digging time, but all growers who sell plants that have been certified are required to sort out any plants showing root-galls. Even when this is carefully done it is likely that a few infected plants escape detection. If raspberry plants are stored in proper cellars or sheds in the winter the root-galls that were not noticed at digging time should develop to a size that makes them easily seen. Therefore, the person who ships the stock in the spring and the purchaser at planting time are in a position to sort out rather accurately any affected plants. The galls in red varieties are confined to the crown or the roots and rarely appear above ground. They may be very small swellings or large tan-colored lumps roughened with nodules on the surface and loosely attached to the roots. In black and purple varieties the galls may occur on the over-wintering canes as tan-colored, rough, swollen areas breaking thru the dark-colored bark. The galls that occur in red varieties on the smaller roots cause relatively little injury to the vigor of the plant. Where the galls occur at the crown or on the canes, as in the black and purple varieties, considerable injury may result. There are no control measures except planting gall-free stock in soil that has not grown other wild or cultivated plants which showed the root-gall disease.

Powdery mildew occasionally occurs in red raspberries. It first becomes apparent on the tips of the new canes after they have reached a height of 2 or 3 feet. The tip leaves are dwarfed in size, mottled, and distorted resembling in many respects red mosaic. The under surface of the leaves shows a water-soaked appearance or white coating which serves to identify it as powdery mildew. The tips make a sharp spike-like growth of a few inches in severe cases and then are permanently halted in growth. The Latham variety is often affected by this disease. Observation indicates that this disease is not likely to occur in New York if the planting is situated so that the air circulates freely on all sides. There are no direct control measures and a heavy infection one year may be followed by complete absence the next.

WINTER INJURY AND ITS PREVENTION

In certain seasons and under certain local conditions, winter injury of the new canes in red varieties may materially reduce or eliminate the following season's crop. The effects on the planting usually are confined to the one season. Winter injury is a more troublesome

factor in red raspberry culture in the Hudson Valley than elsewhere in the State. Black and purple varieties are rarely injured except where poor site conditions prevail which intensify the effect of excessive soil moisture and late or early frost injury.

In red varieties there is a definite relation between the inherent hardiness of the variety and its ability to withstand low winter temperatures. This property is definitely brought out in the colder winter climates of Canada. Thus, the Viking has been proved thoroly hardy for the region of Ottawa and Montreal, Canada. Latham, Chief, and Herbert are generally considered very hardy so far as resisting severe winter temperatures. June and Ontario are sufficiently hardy for the minimum temperatures reached in New York. Newburgh has not been sufficiently tested to make definite statements, but for central and western New York it has proved to be entirely hardy. A few reports of an apparent lack of hardiness in Newburgh from the coastal regions of Massachusetts, Rhode Island, and New Jersey are probably due more to the effect of climatic conditions of this region on the initiation and continuance of dormancy. Lloyd George, an English variety, like most of European origin, is rather tender in New York, but at this Station where cover crops are used every year, it has shown no winter injury since its introduction in 1924. Cuthbert is moderately hardy and may usually be depended upon to come thru the winter uninjured in western New York.

Winter injury of two different types frequently occurs in New York which has little or no relation to the true hardiness of the variety. The inherent varietal hardiness is expressible only when late fall and early spring weather conditions are conducive to the development of complete dormancy, and this dormancy remains unbroken until growth may proceed without injury from freezing. The farther south red raspberries are grown, the more commonly it happens that the new canes are killed back in late fall because the state of dormancy has been delayed. Also, the frequency of dormancy being broken too early in the spring increases with the southerly latitudes and often new canes that have passed the midwinter season safely are killed in February and March. The hardiest of the varieties may show these types of injury.

The fall type of injury is more readily controlled by the grower. The new canes may be killed to the ground in extreme cases or may die back to different heights. Often only the immature tips of the canes are killed, in which case the crop is not reduced because the

slender tips are ordinarily removed at the spring pruning. Immature canes may also be injured near the base. The lesser degrees of injury where the cane or its buds are not killed may show up in various ways the following spring. The fruiting laterals may make only a weak growth that either dies when hot weather comes on or they may fail to mature any profitable fruit due to general weakness. A sudden severe freeze in late fall is much more disastrous to immature canes than a gradual onset of cold weather. The immaturity of the canes is due to late fall growth, usually the result of late cultivation, to excessive fertilization, or to too much soil moisture in the late summer and early fall. The use of a cover crop, as mentioned on page 19, is suggested as the best measure for encouraging early maturing of the canes and thus avoiding fall freezing.

Another cause of late maturing is the practise of pinching back the new canes of red varieties to induce branching. This practise is so likely to cause winter injury that it is very inadvisable. Weak growth of the new canes in midsummer is likely to stimulate renewed growth in the fall after soil moisture conditions improve. The remedy for winter injury which follows such conditions is to attend in the summer to the cultural practises that will permit normal growth and thus avoid the tendency for late growth. Diseases and insects causing leaf injuries must be controlled in the summer in order to avoid renewed active growth in the fall leading to winter injury. Crown injury of the canes during the winter may be guarded against by throwing a furrow of earth up to the canes or otherwise mounding them in late fall.

Certain varieties which inherently lack hardiness must be covered during the winter. The common practise with such varieties is to bend the canes over and cover for the most part with soil. This is usually accomplished by removal of the soil along one side of the row, then the canes are bent over and while held in position soil is placed on them. A furrow of soil may then be turned over them with a plow and smoothed down sufficiently to cover the canes. The work may all be done with a spade in a small planting. Farmers' Bulletin No. 887 of the United States Department of Agriculture illustrates an implement for covering raspberry canes for winter protection. In the spring the canes are uncovered after severe winter weather is past and before any growth starts. The cost of covering has been estimated at $30 to $40 an acre. In view of this cost it is inadvisable to grow non-hardy varieties or to use this method in the place of other

less expensive methods of correcting cultural methods for the hardy varieties.

The spring type of injury is due to seasonal conditions in late winter that bring the plant out of the dormant condition too early. This happens more commonly in the Hudson Valley than in other parts of New York and probably accounts for most of the winter injury in that region. Unseasonably warm weather in late winter is the principal cause of the initiation of the injury. Dormancy is broken and growth processes begin, altho the buds may not show any green. The plants are then subject to injury by low temperatures that would not cause any trouble were they still dormant. In the central and western parts of the State, the presence of large bodies of water and their influence on equalizing rapid temperature changes seems to be sufficiently effective to prevent largely this type of winter injury in raspberries. In general, even in the Hudson Valley, it is not believed that growers will need to lay down and cover the canes of the hardy varieties in order to protect them from the spring type of injury. This injury has been more prevalent the past 2 years in the Hudson Valley because of the unusually mild winters. Particular efforts to insure that the new canes enter the winter fully dormant and giving preference to sites with a northern exposure which tends to warm up more slowly than a southern exposure should be sufficient to insure that varieties known to be naturally hardy for cold winter temperatures will come thru uninjured in the average season.

HARVESTING

Raspberries, because of their perishable nature, require very careful handling. The most common cause of decay is mechanical injury resulting from carelessness in harvesting. No amount of after care can overcome the effects of rough and careless handling in the field. Usually, the field should be picked every other day, or every day if the weather is very hot. During a cool spell it may suffice to pick every 3 days. In any case, pick often enough to avoid any considerable number of over-ripe berries. Soft varieties must be picked more frequently than firm varieties. Proper picking is a matter of thoro organization, proper instruction of pickers in methods of handling berries, constant supervision, and careful inspection of work. With present labor conditions the grower is in a position to insist on good workmanship.

Pickers should be assigned the same rows thruout the season as this will enable the grower to place the responsibility for poor workmanship. Instruct the pickers to pick only one berry at a time and to place it in the basket before picking another. Pick with three fingers instead of two to distribute the pressure on the berry more evenly. Do not attempt to sort or pick berries out of partly filled baskets. Avoid putting in any berries that should later be removed. Discard or put in separate receptacles all over-ripe berries. Growers intending to ship their berries should train the pickers to put the fully ripe berries in one basket and the firm berries suitable for shipping in another. The fully ripe berries may be marketed locally or may go to the canning factory. Do not pick berries until they are mature and will slip off the core without crumbling. Set the carrier in the shade of the row as the berries go down very quickly in the sun. As soon as possible remove the filled baskets to a cool shady spot under trees or in a cool cellar. Never pick wet berries as they will mold quickly.

Varieties vary considerably in their picking qualities. Soft varieties, such as June and Adams 87, require the most careful handling the grower can give them. Latham, which tends to crumble, requires care to prevent tearing the berry apart. Cuthbert and Lloyd George, which turn dark quickly, must be picked early and while still bright red, or they will be unpopular on markets that like bright varieties. Newburgh must be fully ripe to slip off the core readily, but because of its firmness and good keeping qualities will not suffer if not picked as soon as Cuthbert or June.

Varieties with prickly canes and the fruit more or less hidden in the foliage are disliked by the pickers who tend to miss many berries on such varieties. June, Ontario, Latham, and Viking with their smooth canes and fruit borne out in the open are much liked by pickers. Newburgh has prickles but bears its fruit in the open so picking is not difficult. A narrow hedge row is easier to pick than a wide hedge row and supported canes easier than unsupported.

Pint baskets are to be preferred, especially for red raspberries. Consumers prefer pints because of the higher price of quarts, and growers get more for the crop in smaller packages. There is less crushing of berries in pints and they are almost essential for soft varieties. Shallow baskets are preferable as they prevent crushing and offer a larger surface for display. Only clean new baskets should be used. Crates holding 16, 24, and 32 quarts are used, the 24-quart size being most popular. Crates holding 24 pints are popular. The

lighter crates have the advantage of receiving better handling. Loaded crates should not be dropped, jolted, or tipped on end.

A small packing shed is desirable for larger plantings that are not located near the main farm buildings. This will serve as basket storage, provide shade for harvested fruit, and shelter for pickers in case of rain.

Six or eight pickers per acre are usually needed. Adults are preferable, but children over 12 years of age may do good work if properly supervised. A succession of berries from early strawberries thru raspberries and blackberries will enable the grower to build up a smooth-working organization.

MARKETING

Whenever possible berries should be marketed locally to save transportation charges. It is advisable to keep in touch with several markets and investigate the possibilities of cities not situated near centers of production. Small growers are handicapped by a lack of knowledge of available markets from day to day. A cooperative marketing agency enables the development of more distant markets and better distribution of berries. Glutted markets may be relieved by diversion of fruit to canning factories.

A good roadside stand well situated as regards traffic furnishes a good outlet for the crop. A succession of fruits, a fancy pack, high quality varieties, and reasonable prices are factors contributing to the success of roadside marketing. The intimate contact of the grower with the consumer permits the grower to educate his customers regarding varieties and packages.

Growers in regions of high production may well consider the possibilities of growing varieties suitable for shipping and thus develop markets in the more distant larger cities. The Newburgh variety, because of its firm dry texture, is eminently adapted to shipping, and seems to be the most suitable sort for this purpose.

YIELDS

Prospective growers often raise the question as to the yields that may be expected from an acre of raspberries. This question cannot be answered definitely since yields are greatly influenced by rainfall, winter injury, soil fertility, conservation of moisture, cultural practises,

number of canes per acre, pruning, previous season's growth, varieties, and diseases. The following figures are to be considered as only suggestive. According to the 1930 census, the average yield per acre for New York State was 902 quarts. This is low, of course, including as it does old plantings that are past their prime and newly set plantings not yet in full bearing. A fair yield of red raspberries is 2,000 to 2,500 quarts per acre. A high yield is 4,000 quarts to the acre and this will be attained only when excellent cultural conditions prevail. Black raspberry yields should average somewhat higher if the mosaic diseases are held to low amounts.